University of Cambridge
School of Agriculture Memoirs

Memoir No. 30

A summary of the papers published by the members of the Staff of the School of Agriculture and its Associated Research Organisations during the period Oct. 1st, 1957—Sept. 30th, 1958.

Review Series

No. 13. Research in Poultry Genetics at Cambridge

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FOREWORD

This Memoir, which is published under the general editorship of the Librarian of the School, represents an attempt to present as succinctly as possible by means of author summaries the contributions made by members of the Staff of the School of Agriculture and its Associated Research Organisations to the development and progress of Agricultural Science, to indicate to research workers interested the Journals in which the full papers are presented and to act as a complete record of papers published.

Requests for further information or criticism arising out of the summaries should be referred to the individual author concerned; criticisms and suggestions for the improvement of the Memoir itself should be addressed to the Librarian of the School.

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Research in Poultry Genetics at Cambridge.*

by MICHAEL PEASE, M.A.
Late Director of the Poultry Genetics Station

Research in Poultry breeding at Cambridge started with Bateson in 1898. Had he started a year earlier, he would himself have discovered Mendelism before Mendel's discovery was brought to light in 1900. To understand this, we must turn back to the last decade of the nineteenth century. Darwinism, the heresy of 1859, had become the accepted dogma of 1890. According to the then prevailing view, the great diversity of living beings, both wild and domesticated, had come about by selection acting on a continuously varying material This notion had been fortified by Francis Galton's Law of Ancestral Inheritance and later by the statistical researches of Weldon and Pearson: it was supported, too, by the full weight of biological authority, including that of Alfred Russell Wallace.

In this country Bateson alone was a sceptic. Familiar as he was with gardeners and fanciers, he became increasingly aware of the discontinuity of variation in plants and animals. The horticulturalist saved the new variants thrown up from the crossing of existing species: these new types arose ready-made—the continuously varying intermediate steps were absent. There was a wide gap between the theory in the classroom and the practice in the field. In 1894 Bateson published his *Materials for the Study of Variation*[1], a monumental collection of cases of discontinuous variations, or mutations, as we would call them now. But his remained a lone voice, at any rate in this country. He became increasingly convinced that the experimental study of the inheritance of a discontinuous variation offered the best chance of making some advance with the problem of evolution. Accordingly in 1898 he started poultry breeding, crossing Indian Game with White Leghorn in order to study the inheritance of Pea and Single comb. He recorded[2] that the first crosses had either all Pea combs or that they consisted partly of Pea combs and partly of Single combs: and he showed that the F_1 Single comb birds bred true and did not revert to Pea combs or indeed to any intermediate condition. He was here on the very brink of the Mendelian discovery. These experiments were carried out by Bateson and his wife in their garden at Merton House, Grantchester, aided by a very small grant from the Royal Society. Like most beginners at breeding poultry, they ran into trouble with incubators, and disease played havoc with the chicks; their numbers were small and progress was slow.

In 1900, while in the train on his way to London to give a lecture to the Royal Horticultural Society on hybridisation, he read an account of Mendel's work. In a flash he realised the revelation; his lecture was altered accordingly and thus this country first heard of Mendelism. Of the storm that followed, accounts may be read in Mrs Bateson's Memoir[3] and in Punnett's *Early Days of Genetics*[4]. Alone Bateson fought for recognition in this country of Mendel's discovery: publication of his views was several times refused; even the pages of *Nature* were closed against him.

Bateson, of course, realised that experiment alone could resolve the conflict. His enthusiasm fired others at Cambridge to repeat Mendel's experiments and to extend the research to other animals and plants. Miss E. R. Saunders, Miss Durham, R. P. Gregory, and R. H. Lock and others joined Bateson at that time, carrying out experiments which have since become classics. His most notable recruit, however, was R. C. Punnett. Punnett came up from Clifton to Caius in 1895. His career was brilliant: a first in the Natural Sciences Tripos, Walsingham Medal in 1900, a Fellowship in 1901, and Balfour Student in 1904. In that year he joined Bateson and from that notable partnership there flowed an important series of leading discoveries in genetics and particularly in poultry.

Bateson had in 1902 already published[5] his confirmation of Mendel's laws, showing that Pea comb and Rose comb were both dominant to Single comb, and that the White plumage of the White Leghorn was dominant, and that the extra toe of the Dorking was only irregularly dominant, an oddity that has remained a puzzle[6], though Hutchinson's contribution[7] showed

* *This is the thirteenth of a series of articles summarising phases of agricultural research particularly associated with the School of Agriculture since its inception, previous contributions having dealt with:—Physiology of Reproduction, Plant Virus Research, Plant Breeding, Animal Nutrition, Horticulture, Agricultural Economics, Field Drainage, Animal Production, the Cambridge University Farm, Crop Husbandry, Agricultural Teaching and Entomology and Nematology. Further contributions on other work will appear in future issues.*

that the phenomena fell into line with Fisher's theory of dominance. The Second Report to the Royal Society's Evolution Committee in 1905 contained Bateson and Punnett's first joint paper on Poultry[8]: in this they described experiments with Walnut comb and showed that the "blue" plumage of the Blue Andalusian was heterozygous. In the following year, in the Third Report[9] to the Evolution Committee, they described how they had solved the problem of the Walnut comb and recorded the existence of recessive as well as dominant white plumage in poultry. In 1908 (again in the Evolution Committee Report[10]) came the account of the two sorts of recessive white, the Bantam white and the Silkie white, and of how the two crossed together gave coloured birds in F_1, and the 9 : 7 ratio in F_2. Their numbers were substantial, 113 in F_1 and 203 in F_2: the conclusion they drew seems inescapable. But oddly enough no one has ever succeeded in repeating this experiment: the attempt was made on a large scale in America[11], and quite recently a repetition at Cambridge was equally unsuccessful.

About this time they started their experiments with the Silkie breed; it was those experiments which gave them the clue to resolving the puzzle of sex-determination and led to their publication of *The Inheritance of Sex* in 1908[12]. The full results of the Silkie experiments were published in the first volume of the *Journal of Genetics*, which Bateson and Punnett had founded in 1910.

In that same year the partnership was brought to an end by Bateson's departure from Cambridge to become the first Director of the John Innes Horticultural Institution at Merton. Punnett continued the poultry researches at Cambridge and in the following year, 1911, he was joined by P. G. Bailey. Bailey was a man of very great promise; after a first in Natural Sciences, he took the Diploma in Agriculture (as it was then) and along with John Hammond, E. T. Halnan, and J. W. Lesley was in the first batch to be awarded Board of Agriculture Scholarships for Scientific Research. Bailey's career was tragically cut short by the first world war.

After Bateson left Grantchester the poultry pens were transferred to Gravel Hill Farm and rabbits, which had previously been housed in Walter Heape's monkey house in the Zoo. Laboratory, were also brought up to Gravel Hill, being housed in the corrugated iron shed which is now the farm museum. Here Punnett and Bailey set to work on the inheritance of quantitative characters. Though Mendelism had by this time gained general acceptance, a fierce rear-guard action was still being fought round the strong point of quantitative characters. It was a widely held view that while Mendel's rules might hold for structional mutations, for all the important "normal" characters, e.g. weight, stature, rate of growth, coat colour pattern, milk yield and egg production, some other scheme of inheritance held, something more akin to Galton's Law. The notion of multiple factors (polygenes) had been put forward by Nihlson-Ehle[13], but no critical experiments, at any rate in animals, had at that time been carried out. Punnett and Bailey chose weight: from the cross Hamburgh by Selbright poultry[14] they showed that multiple factors fitted the experimental results and could account for an F_2 distribution which gave extreme types heavier than the original Hamburgh at one end and lighter than the Sebright at the other. In rabbits[15], however, the results were disappointing; the expected heavy animals in F_2 were absent. Later, after the war, this experiment with rabbits was repeated more critically and on a much larger scale[16]. In this experiment an F_2 was obtained which gave a normal distribution over the whole range, and it was shown that the extreme types bred true, thus confirming the multiple factor theory in this case.

Punnett and Bailey found an interesting case of quantitative inheritance in shell colour of eggs[17], where they demonstrated the interaction of a major gene with several minor genes. A similar case was found after the war in the coat pattern of the Dutch rabbit[18]. Here, after a long experimental analysis, it was shown that the pattern was controlled by a major and several minor genes. These experiments at Cambridge firmly established the notion of multiple factors on an experimental foundation. Fisher, in an important paper[19], showed that the theory of multiple factors led logically to the statistical results established by Pearson and the biometrical school—that there was, in fact, nothing to fight about.

Before the first war Punnett and Bailey started an experiment on Henny Feathering in poultry[20]. In Sebrights, Campines and some Game varieties the males have exactly the same plumage as the females. From the cross Hamburgh by Sebright, Punnett and Bailey made the "normal" cock-feathered Sebright and showed that Henny Feathering is a simple dominant character. About this time much experimental work was being done on sex-hormones; amongst

other experimenters in this field was the late Dr Francis Marshall of the School of Agriculture. It was known that the ovariectomised hen threw up male feathers and assumed the plumage of the capon. Morgan, the author of the chromosome theory, showed that the castrated Sebright took on the "normal", i.e. cock, plumage[21]. He also made the interesting claim that the testes of henny feathered cocks showed much enlarged interstitial (luteal) tissue and these luteal cells he identified with the hormone which he supposed inhibited normal cock feathering in Sebrights. More careful and critical examination over a period of time of the testes of the cocks from Punnett's experiments at Cambridge[22], however, showed that Morgan had jumped too rashly to his conclusion: the presence or absence of luteal cells, it was shown, depended only on whether spermatogenesis was active or at rest.

After the first war, it was my very good fortune to be asked to take Bailey's vacant place as assistant to Punnett. At first we continued experimenting at Gravel Hill Farm, but in 1923 a special grant from the Board of Agriculture enabled the present laboratory and cottage to be built at Storey's Way, and we were soon hard at work re-erecting the poultry pens on the new and much enlarged site.

During the first war, Punnett had been employed in the Food Production Department of the Board of Agriculture. There he had become impressed by the waste of precious food in rearing unwanted cockerel chicks until their sex became visible[23]. One of the first things therefore that we did after the war was to show that the sex-linkage of Silver/Gold and Barred/Unbarred applied to utility breeds, and that by making use of such crosses, the commercial breeder could save himself the cost of rearing unwanted cockerel chicks. Our first demonstration of this was at the Royal Show at Cambridge in 1922. The exhibit attracted much attention; but it was regarded with utter incredulity by the poultry fraternity. Moreover, sex-linkage crossing ran dead against the cult of the "pure" breed, then at the height of fashion, both with the practical breeder and with the scientist, fortified as the latter was by Johannsen. Gradually, however, sex-linked crossing took on, and today millions of sex-linked chicks are hatched each year all over the world. This was the first practical application of Mendelism to animal breeding on the farm.

Arising out of our experiments on sex-linkage, we became aware that in poultry there are two sorts of barred plumage[24]. The common type, which is found in Barred Rocks, North Holland Blues and Cuckoo Leghorns, is sex-linked. But there is another sort of barring, more sharply marked and finer in amplitude, which occurs in Campines, Grey Bresse, and in Hamburghs. This barring is not sex-linked; it appears to be an ordinary recessive to black plumage. What would be the effect of combining these two sorts of barring, differing, as they do, in amplitude? Would a feather result showing "interference bands"? It was with this end in view that we crossed the Barred Rock with the Gold Campine. Now, as is well known, the Barred Rock has a black down, but the head is splashed with a white patch, the badge of the sex-linked barring gene. The Campine has mottled brown stripe down, recessive to the full black or slaty down. When the F_2 hatched, we kept only those chicks which showed the light head patch on the brown mottled down, as being the chicks combining the recessive Campine barring with the dominant sex-linked barring. These birds turned out to be heterozygous for the sex-linked barring. When mated together in order to give the combination with the homozygous sex-linked barring, we found an entirely new down type turning up. This new type was strikingly paler; the light head patch seemed to have burst its bounds and spread out over the whole dorsal surface, blurring the sharp pattern of the Campine down. These new chicks we rightly surmised to be the homozygotes for sex-linked barring, and therefore to be males. Here, then, was what the poultryman in the field had been calling out for, a new variety of poultry showing a sex-distinction in the downs at hatching, and breeding true to this sex-distinction. We called this new breed the Cambar[25]. The principle of the sex-distinction in the Cambar can be stated quite simply—it depends on the imperfect dominance of the light head patch on a brown down[26, 27]. The Cambar was exhibited for the first time at the World's Poultry Congress in London in 1930, where it excited considerable interest. It was exhibited again in its improved and graded-up form in 1933 at the Rome World's Poultry Congress and again in Leipzig in 1936; and at the Crystal Palace Show in 1935 it gained the Silver Cup which stands in the Professor's room at the School of Agriculture.

In 1930 the Ministry of Agriculture made a grant which enabled new pens and plant to be put up in order to improve the productivity of the Cambar and to extend the range of these new autosexing breeds. Clearly the principle of the Cambar could be applied to any breed having a brown down and breeding reasonably true to its down pattern. To transfer the Barred gene to any "basic" breed having a brown down is but an exercise in simple Mendelian breeding. In this way was made the Barred Brown Leghorn (the Legbar)[28], the Barred Silver Grey Dorking (the Dorbar), and the Barred Brown Sussex (the Brussbar)[29] and also several others. In order that these new varieties might be of use to commercial breeders, it was necessary to step up their productivity. They were therefore graded up on good utility Rhode Island Reds, Light Sussex and other standard types, and in this way their productivity was brought up to a commercial standard. Of these new breeds the Legbar, in both Gold and Silver variants, has been by far the most successful commercially: it has done well at laying trials and is to be found on poultry farms on both sides of the border as well as overseas. The Brussbar was a much later introduction, but it is now being taken up increasingly by practical breeders. It was perhaps unfortunate for these new autosexing Cambridge breeds that the successful introduction to this country of the Japanese method of vent-sexing made autosexing of comparatively less practical importance to the commercial breeders.

Punnett made two more important additions to poultry genetics before and one after his retirement from the Professorship of Genetics. An importation of birds from South America brought in the Blue egg shell, which Punnett showed to be due to a simple dominant gene[30]; these birds also brought in cream plumage, which he showed to be due to a recessive gene which so dilutes the gold colour that to the eye the gold becomes indistinguishable from silver[31]. By incorporating these two genes into the Legbar a new autosexing breed, the Cream Legbar, was made. This, as its name implies has cream plumage and lays blue eggs and in order to distinguish it from the Silver Legbar, it was given a crest. It should be added that the Cambar and all the subsequent autosexing breeds were the first examples of a "utility" animal to be made by planned Mendelian breeding.

In 1957 Punnett showed[40] that in addition to the normal dominant black plumage there was also a recessive black. This recessive gene accounts for the occasional red birds which turn up in the cross Black Leghorn by Rhode Island Red.

Another and totally different piece of genetic research in poultry, with which the School of Agriculture became associated, was inbreeding and the problem of hybrid vigour. In 1930 I had been appointed by the Ministry of Agriculture to be Vice-Chairman of a body, known as the Northern Poultry Breeding Committee, which was in charge of a poultry breeding station at Reaseheath in Cheshire. The members of the Committee were practical poultry breeders in Lancashire and Yorkshire; my task was to supply the scientific direction, which at that time the Committee rather lacked. The members of the Committee were interested in inbreeding: indeed they had already in hand an enquiry into the merits of line breeding[32]. The suggestion that the Committee should follow this up by an experiment on straight inbreeding was favourably received; so in 1932 we started inbreeding by straight continuous brother to sister mating partly to see what happened, and partly with a view to establishing a standardised chicken, like the well known Wistar rat. Notwithstanding many failures, we eventually succeeded in establishing at Reaseheath five lines of White Leghorns bred by continuous brother to sister mating. One of these five lines, it should be gratefully mentioned, was a gift from Professor Waters of Iowa. Much later we established three lines of similarly inbred Rhode Island Reds. Using the White Leghorn inbreds, we showed that Top-crossing[33] (putting inbred males to ordinary commercial stock) gave as good pullets as could be bred by the same dams put to first class outbred sires: and later we showed[34, 35] the incrosses, i.e. inbred lines crossed between themselves, but within one breed, gave pullets of higher, in some crosses much higher, productivity than outbred stock bred commercially. But we failed to get any approach in the inbred lines to that uniformity which we had expected to find after so many years of inbreeding. This led to the suspicion[36] that perhaps in selecting each year the most prolific families to be the parents of the next generation, we had in fact picked out the most heterozygous birds.

In order to test this notion, Dr Gilmour at Cambridge began an investigation into the inheritance of blood-group genes in these five White Leghorn lines. He established the existence of eight genes controlling blood groups; later he showed that both egg production and viability in

these inbred lines increased with increasing heterozygosity of the blood group genes, thus confirming our suspicion that we had in fact over the years been selecting the most heterozygous birds to carry on the lines.

In 1953 the Field Station at Boxworth was put up in order to accommodate stocks of the Reaseheath lines and to expand the research work which these very closely inbred lines made possible. The problem of heterozygosity in these inbred lines can be approached by means of skin grafts. Ordinarily skin grafts "take" only between identical twins. Cock and Clough[38], working at Cambridge, showed that successful grafts could as a rule be made between chicks of the Iowa line. This, however, was not the case with the "C" line, the only other line so far tested. It would seem, then, that the genes concerned are homozygous within the Iowa line, but heterozygous within the "C" line, notwithstanding that both these lines are almost exactly equally inbred.

It has already been mentioned that these inbred lines did not, as we had expected, become increasingly uniform in the characters which we measured. In other animals it had been shown that the progeny from crosses between inbred lines often show far greater uniformity than do the inbred lines from which the crosses were made. Clough and Cock[39] found this to be true, too, in the case of the incrosses from the Reaseheath inbred White Leghorns. It is probable, therefore, that the incrosses from these lines will be found to provide chicks of great value to researchers over a wide field, especially in nutrition and assay work. Already this year these incross chicks have been sent out to several laboratories in this country where assay work is being carried out, in order to compare the variability of the Reaseheath incrosses with that of commercially bred day-old chicks; and up-to-date some most favourable results have been reported.

In 1957 the Agricultural Research Council brought to an end the annual grant which for nearly forty years had made possible research in poultry breeding at Cambridge. The Field Station at Boxworth and the Poultry Institute at Storey's Way have been closed and Mr Cock has been transferred to Edinburgh. Some research in poultry breeding at Cambridge is being continued—but its scope and content is necessarily circumscribed by the financial support which the School of Agriculture may be able to afford.

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AGRICULTURAL ECONOMICS

Planning the Farm to Save Labour. Pp. 45.

Fm Econ. Br. Rep. No. 47, 1958. Price 4s. 6d. Post Free.

In recent years, farmers have begun to pay much more attention to labour costs on the farm. There are two reasons for this: one is the rising cost of wages; the other is the introduction of grants for permanent improvements which will enable farmers to replace their farm buildings.

This report describes an investigation which has lasted over four years. When this study was begun, there were three objectives:

1. To discover how much labour was required to manage livestock.
2. To suggest standards that might be used by the advisory services and farmers.
3. To discover the principles of good design to save labour.

Much still remains to be done to perfect the first and second of these objectives, but it is hoped that the standards given here may be of immediate use and serve as a framework for more detailed research. The third objective—the principles of design—is the one to which most attention has been given. Some of the plans shown are in use; some are not; and the latter are presented as tentative suggestions. Included in the report are chapters dealing with Labour and Milk Production; Labour in Milking; Cowhouse Design; Design of yards for beef production; and Housing of young stock.

Report on Farming 1956–7. Pp. 39.

Fm Econ. Br. Rep. No. 46, 1957. Price 3s. 6d. Post Free.

This survey gives the results of a survey of some 400 farms. In addition to the usual comparison area by area over the province, a brief account is given of the fortune of farms of different type over the past five years. On the whole, arable farms with livestock are more profitable than those without. Nevertheless, arable farms show an upward tendency in income—mainly due to increased cereal yields. During this period, about one-quarter of the farms have changed groups. On the whole, arable farms have added more livestock and have tended to specialise in one or two types rather than three or four as formerly.

Wheat and Barley: Costs and Returns. Pp. 24.

Fm Econ. Br. Mimeogr. Rep. No. 54, 1957. Price 2s. Post Free.

On 72 Hertfordshire farms surveyed in 1956, costs averaged £25 3s. per acre for wheat and £20 15s. for barley. The growing season was on the whole a fair one but harvesting conditions were bad. Yields and profits were respectively 24·6 cwt. and £10 7s. per acre for winter wheat and 24·1 cwt. and £12 3s. for barley. Without the subsidy, wheat profits would have been negligible. After allowing for overheads, a yield of at least 24 cwt. of wheat or 21 cwt. of barley is required to leave a margin over costs of £10 per acre at the 1957 level of costs and prices.

Details are given in this report of the average costs of harvesting by combine and binder, straw costs, labour and tractor requirements, fertiliser use and spraying practice.

1409* Barnard, C. S.

Systems of Milk Production in an Arable Area.

Agriculture, Lond., 1957, **64**, 374–8.

Repr. in *Guernsey Breed. J.* 1958, **12** (1), 39–42.

An analysis of the financial results of arable dairy herds suggests that the traditional pattern of feeding must be changed either to a "high output" or else a "low cost" pattern, if milk production is to remain profitable.

1428* Broadbent, L., Burt, P. E. & Nix, J. S.

Cost of Using Insecticides to Maintain Health of Potato Seed in England and Wales.

N.A.A.S. Quart. 1957, No. 38, 144–52.

The useful life of potato seed stocks in the south and east of Britain can be prolonged by spraying with insecticides which check the spread of aphid-borne viruses. Spread of leaf roll virus from infected to healthy plants within a crop is the main cause of stocks degenerating and this can be almost entirely prevented. Spraying healthy stocks will not prevent viruses being brought into them from other potato crops, but the few plants that become infected in this manner can be removed.

Spraying and roguing to maintain the health of a potato stock costs £8 to £11 per acre less per year than planting new "A" or Stock Seed, but the difference in cost depends on the method adopted and current market prices. The cheapest method is to spray the rogue part of the ware crop and save seed from this, but there may sometimes be advantages to offset the slightly greater cost of growing a crop specially for seed.

1475* Graves, P. E. & Wallace, D. B.
The Changing Farming Pattern.
Agriculture, Lond. 1958, **64**, 531–4.
An examination of the real value of farm incomes in the Eastern Counties based on the Farm Management Survey shows that it stood higher at the end of 1956 than ever before, though there were indications at the end of the period that a downward trend was developing. This high level was due in part to higher real prices but also to greater productivity and greater specialisation. To throw light on this, another analysis was carried out on the types of farming system practised by farmers in the sample in 1958 and 1956. While the constituent farmers had changed over the period, yet it is maintained that the trend towards specialisation and the increase in livestock enterprises are a fair representation of the situation in the districts concerned.

1430* Mackness, R. A.
Seasonality of Beef and Veal Production in Argentina and Consequent Beef Exports.
Emp. J. Exp. Agric. 1958, **26**, 57–63.
This paper presents data of Argentine beef production and export from 1930–54.
Beef production in Argentina was about half a million tons a year greater in 1949 than it was in 1930. The effect of the droughts in 1950–3 is clearly shown. Seasonality of production became more pronounced in 1950–4, compared with the regular monthly pattern of production in earlier years. Before 1938 Argentine chilled beef arrived in the United Kingdom very regularly each month. Between 1949–54 exports of frozen beef from Argentina were markedly seasonal, but were below the general monthly average in the months when United Kingdom home production was seasonally above the monthly average.

1446* Sturrock, F. G.
Promotion of Labour Efficiency and Productivity in Farming in the United Kingdom.
Landbouwk. Tijdschr. 1958, **70**, 29–39.

Wallace, D. B.
Développement de la Vulgarisation de la Gestion des Exploitations Agricoles en Angleterre et au Pays de Galles. Pp. 95–111.
Contr. to *Congrès National sur la Gestion des Exploitations Agricoles. Exposition Universelle, Bruxelles*, July, 1958.
An account of the development of farm management advisory work in England and Wales since 1945.

OTHER PAPERS

BARNARD, C. S. **The Greater Use of Grass and its Economic Significance.** *East. Elect. Fmr.* No. 4, May, 1958.
1450* BARNARD, C. S. **Grassland and the Dairy Cow.** *Westminster Bank Rev.* May, 1958, 8–10.
1445* BARNARD C. S. **Rationing for Cheap Milk.** *Fmrs Wkly.* 1958, **48** (7), 91, 93.
1411* MACKNESS, R. A. **Beef Supplies and Prices in the U.K. since De-control.** *Westminster Bank Rev.* Nov., 1957, 10–12.
1473* NIX, J. S. **What Will it Cost?** *Pract. Power Fmg.* 1958, **20** (5), 13.
RIDGEON, R. F. **Pointers to Pig Profits.** *Fmr and Stk-Breed.* 1958, **72** (3563), 63, 65.
RIDGEON, R. F. **Money in the Heavy Pig.** *Fmrs Wkly.* 1958, **48** (15), 80–1, 83.
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STURROCK, F. G. **Designing Cattle Yards to Save Labour.** *Esso Fmr.* 1958, **10** (2), 14–17.
1474* WALLACE, D. B. **The L.s.d. of Mechanisation.** *Fm Mech.* 1958, **10** (104), 56–7.
WALLACE, D. B. **The Part-time Flock.** *Fmrs Wkly* (Suppl.), August, 1958, 21–2.
WALLACE, D. B. **Simple Accounts.** Parts 1–9. *Fmr and Stk-Breed.* 1958, **72** (3578), 55, 57; **72** (3581), 71, 73; **72** (3582), 65; **72** (3585), 77; **72** (3588), 64–5; **72** (3590), 81; **72** (3591), 49; **72** (3593), 77, 79; **72** (3595), 55.
1482* WHETHAM, E. M. **Rent and the Agricultural Price Review.** *Econ. J.* 1958, **68**, 605–10.

AGRICULTURAL ENGINEERING

1455* Ede, A. N.
Resistance of Concrete Pumped through Pipelines.
Mag. Concr. Res. 1957, **9** (22), 129–40.
The lack of adequate data made necessary the investigation of the basic mechanics of concrete pumping. Unsaturated materials pass stresses by inter-particle contact and give rise on commencement of movement to a pressure build-up which in a non-tapering duct is exponential with distance pumped. Adequate saturation by water/cement paste reduces the resistance to a favourable linear type, subject to increase with velocity, but independent of operating pressure.

1460* Ede, A. N.
The Sleeve Pump for Semi-solids.
Mag. Congr. Res. 1958, **10** (28), 17–22.
A pumping cycle has been designed for initially unsaturated fragmentary materials which makes use of the pumped material jammed in a tubular sleeve as a piston for forcing forward further material in an outlet barrel. The return stroke of the sleeve is made at rapid acceleration, releasing the material in the forward position and resetting the sleeve for a further cycle. Preliminary performance figures and the means of application to concrete pumping are given.

1431* Palmer, J.

An Examination of the Interaction of Harmonic Treatments.

J. Agric. Engng Res. 1958, **3**, 47–56.

Harmonic treatments of crops, such as down-the-row thinning and precision seeding, are represented mathematically and the interaction of two and three such treatments is analysed. Equations are derived which define treatments that produce constant results irrespective of phase relationships between treatments.

Down-the-row thinning of random brairds is examined and it is shown that conventional thinning treatments are in accordance with theoretical requirements. The combined effects of down-the-row thinning and precision seeding are then examined and it is shown that if spacing between potential survivor zones is to be constant, the harmonic characteristics of the seeder and thinner must be matched.

AGRICULTURE

Engledow, F. L.

Agricultural Policy in the Federation of Rhodesia and Nyasaland: Report to the Minister of Agriculture by the Federal Standing Committee on Agricultural Production, in collaboration with Professor Sir Frank Engledow. Pp. 88, with 1 map. Salisbury, 1958.

The Committee's duty was to study and make recommendations on agricultural policy from the point of view both of development and of the Agricultural Services responsible for development.

From an examination of the physical, biological, economic and social factors affecting Agriculture and Forestry and a review of the various existing systems of farming, both African and European, principles for a policy of agricultural development are enunciated. In searching for these principles, the special circumstances of three different territories (Southern Rhodesia, Northern Rhodesia and Nyasaland) have to be allowed for and, similarly, the widely varying characteristics of African peasant agriculture and European commercial farming.

The aim of policy is taken to be: "to use the land for the promotion of the long-term interest of the nation".

Nutrition, an important aspect of the national interest, is characterised by a still low but rising food standard in the African population. The effects of this rise will be strongly shown in the future demand, by kind and amount, for agricultural products.

Complex social and economic issues are involved in policy including the size of holding in the African Reserves, the traditional non-economic attitude towards livestock and the intermittent absence from the land of adult males working in industry often in distant places. Size of working unit in European agriculture and for African farming on the commercial scale also comes into consideration.

What production is possible is governed by the physical limitations such as soil and climate modified by irrigation and other controls. Within limits of what is physically possible it must then be decided what development is in the best interest of the nation. Five criteria are suggested:

(*a*) labour available;
(*b*) capital available;
(*c*) economic stability for the individual farmer and for the whole agricultural industry;
(*d*) sound use of land, water and other natural resources;
(*e*) amount and kinds of food the country requires and how they may best be obtained.

The Committee supports the principle of a reasonable degree of stability in farm incomes for the long-term benefit of consumers as well as of producers and for the proper use and conservation of natural resources.

In applying the above criteria the right principle for policy is priority of development in the inherently best areas, subject to any relevant non-agricultural considerations.

In considering the food supplies required [(*e*) above] maize is recognised as occupying a key position in the agriculture of the Federation. Policy should aim at producing the full maize requirements and it must be accepted that in good seasons this will lead to surpluses. At the same time, everything must be done to reduce the costs of its production, as the price of maize is reflected throughout the national economy; indirectly as a component cost of livestock products, and directly as the main item of diet of the African population. As an important factor in reducing production costs of all agricultural commodities, the Committee advises a greater emphasis on direct production subsidies rather than on indirect price subsidies.

The chief crop and livestock products are severally reviewed in relation to principles enunciated for policy, proposals being made for immediate development, research or other action. Products range from maize and sorghum to wheat and barley, from tobacco (the great cash crop of Southern Rhodesia) to sugar, cotton and tea (the dominant cash crop of Nyasaland).

The function and desirable composition of the Agricultural Services (research and advisory or extension) were also fully examined in the light of the requirements of the policy already enunciated. It was concluded that agricultural development had in recent years advanced so greatly as to require the setting up of separate specialist services in the form of a Central Research Organisation. An Agricultural Research Council enjoying strong independence would be in charge of these research services which would be free from routine advisory work though responsible for highly specialised advice. The practical responsibilities of the existing Conservation, and Extension Services would change somewhat in character because, through its past endeavours, conservation is coming to be an accepted responsibility of every farmer. Greater facilities for investigational work by which to provide new advisory knowledge should, however, be afforded to this service. Full proposals for re-organisation are made.

Mansfield, W. S.
The University Farm, 1957.
Golden Sheaf. 1958, **10** (1), 9–11.

ANIMAL BREEDING AND GENETICS

1457* Cock, A. G. & Simonsen, M.
Immunological Attack on Newborn Chickens by Injected Adult Cells.
Immunology. 1958, **1**, 103–110.
When blood from pure *I* adult fowls is injected into newly hatched chicks of a cross between two highly inbred lines of White Leghorn (*C* and *I*) gross enlargement of the spleen and liver results. F_1 blood injected in F_1 chicks, and either *I* or F_1 blood injected into *I* chicks, produce only a relatively slight enlargement, which is attributable to antigenic diversity within the *C* line, and to a much lesser extent within the *I* line, already known to exist from skin grafting tests. This strongly supports the hypothesis that these symptoms, together with haemolytic anaemia and other associated symptoms described by Simonsen (1957), are due to an immune reaction of the injected cells against the host. This implies that chicken leucocytes are capable of initiating antibody production and transplantation immunity. Subcutaneous injections of blood sometimes produce swellings at the site of injection. No symptoms were found in F_1 adults into which *I* blood had been injected; the reason for this is not known.

Cock, A. G.
Poultry on the Farm. End of the Beginning.
Fmrs' Wkly. 1957, **47** (12), 113–7.

Gilmour, D. G.
Maintenance of Segregation of Blood Group Genes during Inbreeding in Chickens [*Abstract only*].
Heredity. 1958, **12**, 141–2.

Hammond, J.
Darwin and Animal Breeding. Pp. 85–101.
Contr. to A Century of Darwin. Ed. by S. A. Barnett.
(Heinemann, London, 1958. Price 30s.)

1426* Hammond, J.
Historical Sketch of the Early Development of British Farm Livestock Breeds as Represented in the Rothamsted Collection. Pp. 21–35.
Contr. to Prints and Paintings of British Farm Livestock 1780–1910, by D. H. Boalch (Rothamsted Experimental Station, Harpenden, 1958. Price 21s.)

ANIMAL NUTRITION

1413* Bruno, Dorothy & Carpenter, K. J.
A Modified Procedure for the Estimation of "Available Lysine" in Food Proteins.
Biochem. J. 1957, **67**, 13P.
A procedure is described for estimating the number of reactive ϵ-NH_2 lysine groups in the proteins of whole foods. It follows an earlier procedure (Carpenter & Ellinger, *Biochem. J.*, 1955, **61**, 11P) in allowing fluorodinitrobenzene to react with the whole food, and acid-hydrolysing to release ϵ-DNP-lysine, but in addition to giving an ether wash to remove some interfering coloured compounds, a further separation procedure is included. The ether-washed hydrolysate is adjusted to pH 8·5 and shaken with methoxycarbonyl chloride, which results in the quantitative reaction of the DNP-lysine to a derivative which can be extracted with ether, leaving behind interfering compounds that remain insoluble in ether. This appears to eliminate difficulties previously encountered when analysing vegetable materials.

1447* Carpenter, K. J.
Evaluation of Protein Concentrates for Pigs and Poultry.
Agric. Progr. 1957, **32**, 28–30.
This lecture to the Agricultural Chemistry Section of the Agricultural Education Association discusses the problem of applying information obtained in the research laboratory to the formulation of practical diets. The common measurement of the "biological value" of a protein is made with rats receiving a purified diet in which the test material is the only source of protein. In practical pig and poultry rations, protein concentrates are used to supplement the protein supplied by the cereal part of the ration. The cereals differ among themselves to some extent in the amino-acid composition of their proteins; so do stock of different ages in their

requirements for amino-acids. However, under almost all practical conditions once the requirements for lysine and "methionine + cystine" are satisfied there will be no other deficiences. Any laboratory tests which can demonstrate that these amino-acids are present in a sample of concentrate at the required levels should therefore provide a good assurance that the sample is of the quality required for inclusion in a practical ration.

1441* CARPENTER, K. J.

Available Lysine in Protein Concentrates.

Voeding. 1958, **19**, 152–63.

Results are reported on the application of the analytical procedures for "available lysine" to a range of feeding-stuffs including fish, whale, oil-seed and grass products. They show a close correlation with the results of "protein quality" assays carried out with young growing chicks. The chemical procedure appears to be able to detect differences in the value of foods as a source of lysine that are due both to variations in the composition of the raw material, and to heat-damage during processing that can reduce the availability of the lysine present without actually destroying it.

1437* CARPENTER, K. J.

Chemical Methods of Evaluating Protein Quality.

Proc. Nutr. Soc. 1958, **17**, 91–100.

This contribution, part of a symposium on "The Nutritive Value of Proteins", discusses methods that can be used in a routine laboratory to check whether or not a particular sample of a protein food has its expected nutritive value. No method is applicable to all foods, or for detecting every kind of damage. With soyabeans that require a degree of heating to make them digestible the destruction of the enzyme urease can form the basis of a simple test for adequate toasting. With all vegetable foods damage can be caused also by excessive heating during manufacture and progress has been made in relating this to decreased solubility of the proteins in various solvents. With animal products the composition of raw material can also vary to an important extent, so that more complex methods based on determination of key amino-acids seem unavoidable.

1434* CARPENTER, K. J.

A Note on the Chemical Composition of Fish Meals used in a Hatchability Experiment.

J. Agric. Sci. 1958, **50**, 113.

It was reported by Coles (*J. Agric. Sci.*, 1957, **49**, 95) that for four pens of breeding hens each receiving 10 per cent. of a different fish meal, hatchability was lowest from the pen receiving the meal that was darkest in colour, and a possible relationship between "heat-damage to protein" and hatchability was suggested. However, analysis of the meals indicates that the "available lysine" (an indicator of heat-damage) was not lower in the darkest meal. This meal showed a high extractable fat content (6·3 per cent.). The excess colour was removed by extraction with ether which indicated that it resulted from oxidation of fatty material rather than from over-heated protein.

1422* CARPENTER, K. J. & CLEGG, K. M.†

The Relative Value of Three Cereals as Protein Sources for Growing Chickens.

Brit. J. Nutr. 1957, **11**, 358–64.

Fifty-six individually caged growing pullets in a randomised block design were given rations designed to supply daily, per kg. live weight, 12 g. crude protein and 300 Cal. metabolisable energy.

Each of the eight experimental rations contributed 6·75 g. protein from a cereal (maize, oats, barley or a mixture of the three) and 3·75 g. from a protein concentrate (either fish meal or groundnut meal).

In seven complete replications, one 7-week-old pullet was allotted to each of the eight rations. After 5 days for adjustment to the ration a nitrogen-balance trial was conducted for two successive 5-day periods.

For each protein concentrate nitrogen retention was significantly lower when barley was the cereal. Nitrogen retentions with maize, oats and a mixture of the three cereals did not differ significantly

The fish-meal sample gave better retention than groundnut meal regardless of the cereal used, and there was no evidence of cereal × supplement interaction.

† Work carried out at the Rowett Research Institute, Bucksburn, Aberdeen.

1406* CARPENTER, K. J., GOTIS, A. & HEGSTED, D. M.‡

Estimation of Total Cholesterol in Serum by a Micro-Method.

Clin. Chem. 1957, **3**, 233–8.

A micro-method for the estimation of total cholesterol in tissues (Albers & Lowry, *Anal. Chem.*, 1955, **27**, 1829) has been adopted for use with small volumes of serum, so as to allow repeated blood sampling during the course of experiments. 0·02 ml. serum was digested with alcoholic KOH, and the cholesterol extracted with petroleum ether. After evaporation of the ether extract the residue was re-dissolved in 2 ml. trichloroethane-acetic anhydride. After 15 minutes, 0·08 ml. of sulphuric acid was added with shaking and the resulting fluorescence in ultra-violet light measured after a further 30 minutes. The results with a large series of rat and human sera samples agreed closely with replicate values obtained by a standard procedure.

‡ Work carried out at the Department of Nutrition, Harvard School of Public Health, Boston, Mass., U.S.A.

1453* Evans, R. E.

Nutrition of the Bacon Pig. XIX. Requirement of the Bacon Pig for certain Essential Amino Acids.

J. Agric. Sci. 1958, **50**, 230–42.

The addition of essential amino acids to all-vegetable diets, so as to raise the biological value of their proteins to the level of animal-protein concentrates, has often been advocated in the past by animal nutritionists. This aim was frustrated in practice since it was impossible, until recently, to secure the necessary supplies at prices that would make such additions economical. Feeding stuffs with added amino acids are now being sold commercially. This is possible following the manufacture of synthetic DL-methionine and crude L-lysine monochloride. It seemed desirable, therefore, to carry out investigations into the potential value of these amino acids to the pig feeder. This paper deals with the effect on growth, food utilisation and retention of nitrogen of adding small amounts of lysine and methionine to the diet. An attempt is made to correlate the amino acid composition of the pig's diet with its rate of growth, the energy supply being adequate.

The approximate amino-acid composition of rations shown in previous work to support maximum growth is given. A comparison is made of the supply of amino acids when a cereal diet is supplemented with minimum amounts of white-fish meal, ex. dec. groundnut meal and ex. soya-bean meal. These amounts are compared with standards laid down by the sub-committee on swine nutrition of the U.S.A. as published in *Nutrient Requirements for Swine*. The comparison indicated a possible deficiency in lysine and methionine as limiting factors in securing maximum growth and food utilisation. The American data give added confirmation to our work on the minimum protein requirement of pigs in spite of the somewhat higher energy content of American diets.

The results of the first nitrogen-balance trial and of the first growth trial show that a diet supplying about 0·76 per cent. of lysine will enable weanling pigs to make very satisfactory live-weight gains of approximately 0·95 lb. per day between weaning and around 80 lb. The addition of 0·1 or 0·2 per cent. of L-lysine monochloride brought about a further slight improvement in the growth rate and retention of nitrogen, but the effect was too small to make such additions worthwhile. Thus, the standard diet supplemented with 7 per cent. of white-fish meal or a similar diet supplemented with 15 per cent. of ex. soya-bean meal contained about the minimum amount of lysine.

When the cereal diet was supplemented with 20 per cent. of ex. dec. groundnut meal, the utilisation of the nitrogen in the food was improved, and the percentage eliminated in the urine was reduced as a result of adding 0·2 per cent. L-lysine plus 0·2 per cent. DL-methionine to the diet. This finding was confirmed in the second growth trial when the mean rate of live-weight increase improved from 0·86–0·98 lb. as a result of adding the amino acids. The saving in meal over the period between 35 and 80 lb. live weight amounted to about 16 lb. The addition of methionine alone to the groundnut diet improved the rate of live-weight gain from 0·86–0·91 lb. with a saving of only about 6 lb. of meal. It is calculated that the groundnut diet supplied about 0·6 per cent. lysine and 0·53 per cent. methionine plus cystine. The latter probably represents about the minimum requirement of the weanling pig but the lysine supply is suboptimal. It was again concluded that in order to obtain maximum growth the lysine supply should be between 0·7 and 0·8 per cent. of the diet.

In the period between 90 and 150 lb. live weight the requirement for lysine appears to be much lower being only about 0·37 per cent. and that for methionine plus cystine 0·36 per cent. Further work is in progress on the practical application of these findings.

1421* Hammond, J.

Zucht und Ernährung auf Frühreife in ihrer Auswirkung auf die Fruchtbarkeit.

Züchtungskunde. 1957, **29**, 483–90.

The rapidity with which farm animals can be multiplied depends on four main factors:—(1) age at which they first breed; (2) number of young at a birth; (3) the frequency of births; and (4) the length of breeding life. The effects of nutrition on each of these factors is discussed.

Leat, W. M. F. *with others.*†

Nature and Properties of SA (Ubiquinone).

Biochem. J. 1958, **68**, 16P.

Leat, W. M. F.†

Ubiquinone.

Chem. & Ind. 1957, 1649–50.

† Work carried out at the Department of Biochemistry, University of Liverpoo

ANIMAL PHYSIOLOGY AND PRODUCTION

1412* Brookes, A. J. & Latham, J. O.

Investigations into Problems Involved in the Production of Beef from Dairy-bred Steers.

Emp. J. Exp. Agric. 1958, **25**, 339–55.

The dependence of the home beef industry upon the dairy industry for the supply of suitable calves for rearing for beef is discussed.

Reference is made to the beef-production experiments on the Cambridge University Farm, in which the value of a good start in life for the calf destined for beef has been demonstrated and measured.

A survey involving following large numbers of dairy-bred steers from commercial farms to the slaughter-house to assess the type of carcass produced under various environmental conditions has recently been started. Most attention is being devoted to Friesian and Dairy Shorthorn steers and the steers obtained by crossing cows of these two breeds with beef bulls.

Carcasses obtained from cattle in this survey are measured and compared with Argentine chilled beef. A smaller number of carcasses are examined in greater detail by jointing, to obtain information on the proportions of the various parts and the variation which occurs in practice.

Plans for weighing cattle in this survey at various ages to assess growth-rates and economy of food conversion at various stages of life are mentioned.

A small-scale investigation into the quality of meat produced by immature and 2-year-old Friesian and Angus × Friesian cattle is described and the carcasses are compared with that of a mature Friesian bullock and also with chilled Argentine beef. The carcasses were very similar in many respects, but the mature Friesian bullock had a good deal more trimmable fat in the hindquarters. In all cases the proportions of the quarter represented by various joints were remarkably similar. This investigation is to be repeated.

The husbandry angle of producing light-weight fat cattle from dairy-bred steers is briefly discussed and an approximate economic assessment made. The profitability to the farmer of producing young light-weight cattle (2 years old) is compared with that of older mature cattle (2½–3 years old).

An inquiry into cheaper wintering systems possible for beef cattle has recently been started.

1470* Carpenter, K. J. & Mayer, J.†

Physiologic Observations on Yellow Obesity in the Mouse.

Amer. J. Physiol. 1958, **193**, 499–504.

In our colony, yellow obese mice were longer than nonobese littermates and yellow males were heavier than yellow females. Weight gain was greatest on high fat diets. If the yellow mice were given a possibility to exercise (activity cages), they lost weight. Resistance to cold was good. Fasted blood glucose levels were normal, fed levels frequently elevated in males. Yellow male and female mice showed a degree of insulin resistance; yellow males showed a marked hyperglycemic response to growth hormone, ACTH, cortisone, and glucagon. Blood total lipids were elevated in yellow mice, with the females exhibiting hypercholesterolemia. As in other forms of "metabolic" obesity, blood ketones were decreased by an 18 hours fast.

† Work carried out at the Department of Nutrition, Harvard School of Public Health, Mass., U.S.A.

Everitt, G. C.

A Survey of Beef Production in the East Anglian Area of England.

Pp. 70 + 2 Appendices, 11 Figures and 12 Tables. *Cyclostyled.*

This report presents the results of a survey of beef production in the East Anglian area of England between October, 1956 and September, 1957.

It forms an integral part of a more extensive survey of beef production and carcass quality in England and Wales, which commenced in 1956.

1448* Gordon, I.

Use of Progesterone and Serum Gonadotrophin (P.M.S.) in the Control of Fertility in Sheep. I. Hormonal Augmentation of Fertility in the Ewe during the Breeding Season.

J. Agric. Sci. 1958, **50**, 123–51.

Over four breeding seasons (1952–6) field trials, involving a total of 2504 treated and control ewes of nine breeds (Romney, Clun, Suffolk, Cheviot, Lincoln, Welsh Mountain, Ryeland, Southdown and Hampshire) were conducted in an attempt to increase flock fertility by injections of P.M.S. hormone. The hormone employed was in three forms of preparation: purified, freeze-dried and whole serum. Dosage levels from 250–1000 i.u. were injected subcutaneously.

There is no evidence that the treatment affected the ability of the ewe to conceive.

A significant increase in fertility was induced by treatment. The extent of the increase apparently depended on the dosage level and form of P.M.S. employed, and was found to be affected by the normal fertility status of the sheep undergoing treatment. At any given dosage level of P.M.S. the increases induced by treatment were greatest where flock fertility was very low.

When used at comparable dosage levels, whole serum tended to be more effective in inducing super-fertility than freeze-dried or purified serum. Freeze-dried serum tended to be more effective than purified serum.

1047 injected sheep that conceived to service at the treatment oestrus produced 1898 lambs (1·81 lambs per ewe); 997 control ewes that conceived at the same time produced 1506 (1·51 lambs per ewe).

There was no evidence that treatment affected the lambing percentage in ewes failing to conceive to first service. 151 injected ewes that conceived at return service produced 188 lambs (1·25 lambs per ewe) and 140 comparable and untreated sheep produced 180 lambs (1·29 lambs per ewe).

35·5 per cent. of injected ewes that conceived to first service produced singles, 51·6 per cent. twins, 9·7 per cent. triplets, 2·6 per cent. quadruplets, and 0·6 per cent. produced litters containing five or more lambs. 51·4 per cent. of controls produced singles, 46·2 per cent. twins, and 2·4 per cent. triplets. Litter-size was

affected by P.M.S. dosage-level. Of 567 ewes injected with 250–600 P.M.S. none produced a litter containing more than four lambs. Doses of 750–1000 i.u. administered to 712 ewes resulted in some litters containing five or more lambs.

In treated sheep the percentage mortality in lambs up to 1 day of age was 6·5 per cent. in singles, 10·5 per cent. in twins, 20·9 per cent. in triplets, 38·9 per cent. in quadruplets and 90·6 per cent in quintuplets. In control sheep the percentage mortality was 6·4 per cent. in singles, 9·3 per cent. in twins and 13·9 per cent. in triplets.

Such mortality was reflected in lambing percentages by a reduction from 1·63 lambs per injected ewe to 1·40, and in controls from 1·38 to 1·26. In 940 injected and 889 control sheep, the survival of lambs was observed for 2 weeks after lambing. In the injected sheep lambs per ewe decreased from 1·65 at birth, to 1·39 alive at 1 day and 1·34 alive at 2 weeks. In the controls, the number produced per ewe at birth was 1·37, and this average was reduced to 1·24 at 1 day, and to 1·21 at 2 weeks.

In Welsh Mountain ewes the use of progesterone before injection with P.M.S. led to the synchronisation of oestrus in a high percentage of sheep and to an increase over controls in the percentage producing multiple-lambs.

The results from trials are briefly discussed in relation to the possible practical utility of this form of treatment under British conditions.

1449* Gordon, I.

Use of Progesterone and Serum Gonadotrophin (P.M.S.) in the Control of Fertility in Sheep. II. Studies in the Extra-seasonal Production of Lambs.

J. Agric. Sci. 1958, **50**, 152–97.

In the course of four non-breeding seasons (1953–6) experiments were conducted with 1504 ewes. The experiments are discussed in six sections, each of which deals with a particular aspect of the problem of extra-seasonal lamb production.

1. 189 ewes, of various breeds and crosses, were treated with progesterone followed by P.M.S. to induce coincident oestrus and ovulation.

41 ewes were slaughtered 41–120 hours after estimated onset of oestrus and 81·3 per cent. of the 92 recovered ova were cleaved. 48 ewes were slaughtered 20 22 days after induced matings and 67 per cent. possessed one or more apparently viable embryos.

There was no evidence that fertility in the Suffolk rams employed in these matings decreased to the point where fertilisation of ova was affected.

2. 692 ewes, including 440 in milk, were injected with P.M.S. alone, progesterone alone, or progesterone followed by P.M.S. The percentage of ewes in oestrus (oestrous response) was greater in those receiving progesterone alone in divided doses over 5–7 days than in those receiving similar treatment over a 3-day period. P.M.S. and progesterone, injected separately induced a low oestrous response. 389 of the injected ewes were observed for autumn lambings and 125 (32 per cent.) produced lambs. The percentage of non-lactating ewes which produced lambs (44 per cent.) was greater than that in lactating ewes (27 per cent.) 184 lambs were born: 59·2 per cent. of ewes produced singles 34·4 per cent. twins and 6·4 per cent. triplets.

3. 426 non-lactating ewes were used in field trials in "early lamb" production. 229 (69·2 per cent.) of 331 ewes treated with progesterone in oil and followed by an injection of P.M.S. came in oestrus 1–7 days after. A higher response followed longer progesterone treatment (5 days) than shorter (3 days): 28 of 54 ewes injected with a micro-crystal suspension of progesterone and P.M.S. later came in oestrus. A much lower response followed treatment with P.M.S. only.

236 ewes were observed at lambing time and 131 (54·3 per cent.) produced young to service at first induced oestrus. 59·5 per cent. of ewes produced singles, 38·3 per cent. twins and 2·3 per cent. triplets.

Of 92 ewes which came in oestrus one cycle after attempted induced ovulations, 82·6 per cent. produced lambs. No evidence was obtained to suggest that hormonal therapy led to a reduction in the normal percentage of sheep giving birth.

4. 81 ewes that produced lambs in the months of September, October and early November were observed in autumn matings. 15 of the ewes were injected with progesterone followed by P.M.S. approximately 3 weeks post-partum: 66 were allowed to mate without treatment. Hormonal therapy induced oestrus in 5 ewes only. The mean duration of the lactation anoestrus in uninjected sheep was 44 days, the range being 17–75 days. 75·4 per cent. of ewes produced lambs to services at first oestrus, 16·4 per cent. to services at a later oestrus and 8·2 per cent. failed to give birth. Results indicate that autumn lambings do not necessarily reduce subsequent breeding performance in ewes.

5. Studies on the rate of live-weight gain and incidence of mortality were made on 26 lambs produced in October. Average daily gain in weight of 15 Suffolk × Half-Bred lambs was 0·38 lb., and in 11 Shropshire × Clun it was 0·46 lb. Climate was mainly responsible for retardation in growth. Four lambs died 75 105 days after birth as a result of severe worm infestation.

6. 197 ewes were injected with progesterone followed by P.M.S. in an attempt to improve conception rate in out-of-season matings. 11 of 23 rams employed in matings received injections of P.M.S. to stimulate fertility and libido. A higher percentage of maiden than lactating ewes came in oestrus 1–5 days after treatment. There was also a significant difference in conception rate between maiden (69 per cent.) and lactating ewes (14 per cent.). Modification in hormone technique did not improve conception rate, and injection of rams with P.M.S. failed to induce response.

Conception rate in lactating ewes which came in oestrus one ovarian cycle after attempted induced matings was significantly higher (73 per cent.) than that following service at the induced oestrus (14 per cent.).

95 per cent. of maiden ewes that produced lambs in September came in oestrus in October and November. 67 per cent. of these lactating ewes produced young in the following spring. The average daily weight gain in 20 autumn born lambs was 0·48 lb. over a 130-day period, birth to slaughter.

1415* Hammond, J.

Livestock Changes in Norfolk since the Year 1780. Pp. 16.

The Lord Hastings Memorial Lecture, Norwich, 1957 (Norfolk Agricultural Experimental Station, Sprowston).

A short account is given of the native breeds of cattle (White Polled, Old Norfolk and Red Polled) and sheep (Old Norfolk). Changes in the total number of livestock show a marked drop in sheep and rise in cattle possibly owing to the replacement of the swede by sugar beet. Methods of production existing at different times during the period are outlined.

Harrington, G.

Pig Carcass Evaluation. Pp. xii + 107.

Tech. Commun. Bur. Anim. Br., Edin., No. **12**.

(*Commonw. Agric. Bur., Farnham Royal*, 1958. Price 15s.)

This review is concerned with the many different techniques which have been considered in the assessment of quality in pig carcasses, in circumstances ranging from detailed scientific experiments to slaughterhouse grading. The first chapters deal with the estimation of carcass composition (by means of physical and chemical carcass analysis, sample joints, linear measurements, specific gravity determinations, sample borings and the yields of certain cuts), the evaluation of live pigs (by means of the dilution technique, fat soluble indicators, density determinations, X-rays, ultrasonic measurements, back-fat probes, the removal of fat and muscle samples and external body measurements) and other factors affecting carcass quality (including conformation, weight and the qualities of fat and lean meat). A further chapter, which deals with the methods of evaluation used in commercial grading, carcass competitions and progeny testing, includes some comments on the importance of subjective assessments of quality.

The discussion points out the directions which, in the author's opinion, future research on evaluation techniques should take. Aspects of particular interest are the improvement of methods for measuring fatness in carcasses and live pigs, clarification of the role carcass measurements and subjective judgements play, and the study of consumer preferences for meat.

1443* Harrington, G.

Determining the Fatness of Live Pigs.

Agric. Rev., Lond. 1958, **3** (11), 20–25.

Methods devised in recent years for determining the fatness of live pigs are described and discussed. The thickness of back-fat may be measured by probing at various positions on the back either with a flat metal ruler or the commercially marketed device called the "Leanmeter". The latter uses the different electrical resistances of muscle and fat to detect the lower limit of the back-fat layer as the needle is pushed in. X-rays may provide an accurate measurement with pigs that are not too heavy, but the most promising method is that involving ultrasonic waves. With this apparatus it should be possible not only to measure fat thickness in one place but also to study its contours along the back and sides of the animal. The value of this method to boar performance tests is stressed.

As regards the measurement of total body fat, possibilities include the use of fat soluble indicators and determinations of body density by air displacement or helium dilution. None of these methods has yet been tried with pigs. The so-called "dilution technique", whereby fatness is calculated from body water estimated chemically, has been applied to pigs, but the results were disappointing when antipyrene was the solute used. The development of this promising method depends on the discovery of a suitable solute.

1424* Ryle, M.

Studies on the Influence of the Embryonic Environment on the Post-hatching Development of Chickens.

J. Exp. Biol. 1957, **34**, 529–42.

Techniques are described for removing and replacing approximately 15 per cent. of the total volume of yolk after 5 days incubation, or of albumen after 2–3 days, in hens' eggs. These allow up to 50 and 40 per cent. respectively of the eggs to hatch.

Yolk and albumen were exchanged between different breeds of chickens, and chicken eggs received yolk and albumen from other species. Embryonic viability was not reduced by egg constituents of other breeds or species. Small numbers of chickens from eggs which received turkey, goose and duck yolk, and larger numbers from eggs which received turkey albumen, were hatched and reared successfully; they appeared to be quite normal.

Legbar eggs received yolk from Polish Bantam eggs. The experimental birds weighed significantly less than their control siblings at 139 days. The mean shank lengths were not significantly different. Attempts to repeat the experiment failed to support this result; possible reasons for this are discussed.

Polish Bantam eggs received yolk from Dorbar eggs. At 100 days they were significantly heavier than their control siblings, but their mean shank lengths were almost identical.

In each of the four 1955 albumen exchange experiments the mean weight of the experimental birds at 170 days was greater than that of their control siblings, but not significantly so. On pooling the data a significant

difference was found at 100 and 114 days ($P = 0{\cdot}05$) and 170 days ($P < 0{\cdot}02$). The mean shank lengths were very similar. The 1956 experiments failed to confirm these results; possible reasons for this are discussed.

It appears that, in certain circumstances, exposure of the embryo to "foreign" yolk or albumen may influence post-hatching growth in weight, but this effect is only detectable when the chicks are over 3 months old.

OTHER PAPERS

1479* EVERITT, G. C. & POMEROY, R. W. **Home-produced Beef.** *Agriculture, Lond.* 1958, **65**, 275–9.
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1420* HAMMOND, J. **Report on Irish Cattle and Pig Breeding Policy.** *J. Dep. Agric. Eire.* 1956–7, **53**, 11–21.
HAMMOND, J. **Get Your Lambing Percentage Up.** *N.Z. Meat Prod.* 1958, **2** (6), 8–17.
1466* HAMMOND, J. **Hormones in Relation to Animal Production.** *Proc. N.Z. Soc. Anim. Prod.* 1958, **18**, 3–5.
1425* HAMMOND, J. **Meat Production and Science.** *Aberdeen Angus Rev.* 1958 (25), 40–41, 78.
1462* HAMMOND, J. **Research in the Physiology of Reproduction.** *Agric. Rev., Lond.* 1958, **4** (3), 17–21.
1463* HAMMOND, J. **Twins are One Answer to Growing Beef Demand.** *Irish Fmrs' J.* 30 Aug., 1958.
1477* POMEROY, R. W. **Touchstones for Beef.** *Fmrs' Wkly.* 1957, **48** (23), 87, 90.

BIOMETRICS

1410* BRAUDE, R., MITCHELL, K. G. & HARRINGTON, G.
Carcass Length Measurements in Bacon Pigs.
J. Agric. Sci. 1957, **49**, 357–60.

Two experiments involving length measurements of 96 bacon-pig carcasses showed that chopping out the backbones, chilling and laying the carcasses down on a table, each resulted in a decrease in average length. There was variation from carcass to carcass in the magnitude of these decreases which, in the case of the chopping out the backbone and laying down stages, was related to the fatness of the carcass, greater decreases being found in the longer, leaner carcasses than in the shorter, fatter sides.

Estimates of the precision of measuring showed that length from the junction of the first rib and the sternum to the symphysis pubis taken on hanging carcasses was less susceptible to errors than the same measurement taken on the lying carcass, and that both these measurements were more accurate than that from the atlas bone to the symphysis pubis taken on carcasses either hanging or lying.

1432* CAMPBELL, R. C. & JAFFE, W. P.
The Motility of Mixed Semen.
J. Agric. Sci. 1958, **50**, 64–5.

An attempt was made to verify a report that mixed samples of bull semen show better motility and survival than their unmixed controls.

The claim was not confirmed; in 83 of 104 samples the motility score of the mixed sample was less than the score for the better individual constituent sample.

1476* COOPER, D. M. & ROWELL, J. G.
Relations between Fertility, Embryonic Survival and some Semen Characteristics in the Chicken.
Poult. Sci. 1958, **37**, 699–707.

The following qualities were estimated for the semen of each of 30 cocks:—fertility, embryonic survival, pH, resazurin reduction time, percentage of dead spermatozoa, density of all spermatozoa, density of live spermatozoa, motility and volume of ejaculate.

Fertility was significantly correlated with percentage of dead spermatozoa, motility, reduction time and live density; correlations with pH, density of all spermatozoa and volume of ejaculate were not significant.

Evidence is presented to show that the quality of the semen, as measured by the percentage of dead spermatozoa, motility or reduction time, determines a cock's fertilising ability to a greater extent than the density of live spermatozoa.

Reduction time, percentage of dead spermatozoa and motility are highly correlated.

There is some evidence to suggest that the survival of an embryo to hatching depends to a slight extent on the quality of the fertilising spermatozoon.

1472* LONG, P. L. & ROWELL, J. G.
Counting Oocysts of Chicken Coccidia.
Lab. Practice. 1958, **7**, 515–9.

Haemocytometer counts of coccidial oocysts in pure culture have been carried out to determine how accurately it is possible to infect a chicken with a specified number of oocysts. A table is given to show how the standard error depends on the number of oocysts in the fluid and the number of samples taken.

A method is described for counting oocysts in faeces. The basic technique is to add water and break up the faecal matter with a macerator, add a solution of sodium chloride and sample to a test tube, dilute with a saturated solution of sodium chloride and sample to a McMaster counting chamber. Details are given of some precautions which should be taken when using this technique. A formula is given which enables standard errors of estimates to be calculated.

CROP HUSBANDRY

1423* Lazenby, A.†

Some Effects on the Yields of Ryegrass Strains of Varying the Growing Technique and the Conditions of Management.

J. Brit. Grassl. Soc. 1957, **12**, 257–63.

The effects are reported of varying the growing technique, and the conditions of management, on green and air-dry yields of herbage from five strains of ryegrass during 1952 and 1953. All strains were grown in three ways: as spaced plants, in drill-rows and in stands broadcast with white clover. There were two experiments, one managed for hay and aftermath, the other cut more frequently.

In both experiments the broadcast plots reached their peak of herbage production first; the spaced plants took longest. There were considerable differences in the seasonal distribution of yields from the different growing techniques during the first harvest year. In 1953, the differences were smaller but the secondary annual peak of herbage production observed in the broadcast plots was not detected in the spaced plants.

The total annual production per unit area was greatest from the broadcast, and least from space-plant plots. Yields on certain occasions, however, were greatest from spaced plants and least from broadcast areas.

The effects of varying the conditions of management were greatest on population samples sown broadcast and least on those growing as spaced plants, their reaction when grown in drills being intermediate.

Differences in plant population in the various growing techniques are discussed in relation to the above results.

† Work carried out at the Welsh Plant Breeding Station, Aberystwyth.

CROP PESTS AND DISEASES

1471* Dunning, R. A.

Stem Eelworm Invasion of Seedling Sugar Beet and Development of Crown Canker.

Nematologica. 1957, **2** (Suppl.), 362–8.

Previous literature, considering the host range and race of stem eelworm concerned, the symptoms of crown canker, and its influence on yield, and the general distribution of attacks in Europe is reviewed.

Recent work has shown that serious attacks most frequently develop as a result of seedling invasion by eelworms from the soil, and canker develops rapidly in these plants in the autumn. The infested seedlings show various distinct symptoms and, in the case of very early invasion, blindness is produced, which later leads to a multiple-crowned plant. Canker can develop to a limited extent as a result of invasion of healthy plants during the summer and early autumn.

There appear to be differences between beet and mangolds in their susceptibility to invasion and development of canker.

Jones, F. G. W.

Sugar Beet Pests. Pp. 63.

Bull. No. 162, Minist. Agric. 1957. (H.M.S.O., London. Price 6s. 6d.)

McKinlay, K. S. & Geering, Q. A.†

Studies of Crop Loss following Insect Attack on Cotton in East Africa. I. Experiments in Uganda and Tanganyika.

Bull. Ent. Res. 1957, **48**, 833–49.

The loss of crop following insect attack on cotton was studied in 1950–4 at the Cotton Research Station, Namulonge, which is situated in the elephant-grass zone of Uganda, in which the principal pest of cotton was originally considered to be *Lygus vosseleri* Popp. In 1953, the main invasion of cotton by *Lygus* occurred during September and October, originating from cultivated crops of black gram (*Phaseolus mungo*) and sorghum and from the wild perennial legume, *Pseudarthria* sp., which earlier workers had considered important. Trials in this zone have demonstrated, over a number of years, that early June is the optimum date for sowing cotton, although such sowings receive the heaviest attack by *L. vosseleri*. Experiments to determine the maximum loss of yield due to *Lygus* should therefore be made with cotton sown at this time. Bollworms are also important pests, notably *Heliothis armigera* (Hb.) and *Earias* spp., their attacks following those of *Lygus* and being heaviest in October–November.

An experimental procedure was devised to evaluate the effects of the two principal types of pest. This depended upon the fact that single rows of cotton treated at weekly intervals with an appropriate insecticide and sited among larger areas of untreated cotton are protected against attack by *Lygus*, the adults of which are mobile and are repelled, and by bollworms of various species, which are killed. The two types of pest differ in their time of incidence, that of *Lygus* being mainly in the early part of the cotton plant's life, and that of bollworm later; cotton may therefore be protected against either or both, according to whether the

insecticide is applied early, late or both early and late. In 1953–4, the three treatments consisted of weekly applications, to run-off, of a spray containing 0·2 per cent. D.D.T. in suspension to 25-ft. lengths of single rows of early-sown (9th June) cotton, separated from each other by seven untreated rows, during August–September, October–November and August–November, respectively; a similarly arranged, untreated row-length was used as control. The treatments were replicated in each of three widely separated areas on the Research Station, and the whole experiment was repeated, with an appropriate alteration in the timing of the treatments, on late-sown (10th August) cotton. Similar experiments were also made in which more restricted periods of protection were employed. Yields were recorded, and crop development was followed throughout the season, on each single-row plot.

On the early-sown cotton, protection from insect attack for the maximum period (four months) did not increase yield, but caused the crop to form earlier. On late-sown cotton, protection by insecticides was accompanied by increases in yield in all localities, although maximum protection did not necessarily give the greatest increase. It thus appears that where a sufficiently long growing season can be achieved by early sowing, as in the elephant-grass zone of Uganda, the cotton crop can replace a considerable loss of flower buds and bolls by subsequent growth, to the extent that total yield is unaffected.

In order to investigate the situation in an area with a single rainy season, shorter growing period, and more intense insect attack, two experiments were conducted at Ilonga, in eastern Tanganyika, where infestations of cotton by *H. armigera* are usually severe. In the first, cotton was sown early (31st January) and completely protected from insect attack by weekly applications of a spray containing 0·2 per cent. toxaphene. Insect damage was then simulated by removing flower buds for periods varying from 4–12 weeks. Owing to a high experimental error, yield differences were not statistically significant, but plants that had been disbudded for 12 weeks eventually yielded almost the same amount of cotton, although in a very much shorter period, as those not disbudded at all. The second experiment was a formal comparison of the control of *H. armigera* achieved by different insecticidal treatments on cotton sown late (23rd March). All treatments gave highly significant increases in yield, the best being a dust containing 10 per cent. D.D.T. plus 3 per cent. γ B.H.C., and an emulsion spray containing 0·8 per cent. D.D.T. plus 0·25 per cent. γ B.H.C., which yielded 968 and 973 lb. seed cotton per acre, respectively, compared with 211 lb. from the control. It thus appeared that even under the conditions at Ilonga, cotton can recover from considerable loss of fruiting bodies, provided it is sown sufficiently early, although late-sown cotton has even less chance of recovery from such damage than it has in Uganda.

These results, in conjunction with those from similar work elsewhere, including the United States, tend to show that the cotton plant, owing to its method of growth and crop formation, has remarkable powers of recovery from insect damage. It is only when damage exceeds the point at which recovery is still possible that insecticides will increase yields. Any factors tending to reduce the length of the growing season, or any increase in the severity of the insect attack, will reduce the plant's powers of recovery and make more likely the need for insecticidal control, but it is evident that the presence of insects feeding on the plant does not always mean that such control would be necessary or profitable.

† Work carried out at the Cotton Research Station, Namulonge, Uganda.

1458* Shepherd, Audrey M.

Experimental Methods in Testing for Resistance to Beet Eelworm, *Heterodera Schachtii* Schmidt.

Nematologica. 1958, **3**, 127–35.

After a short review of previous work on testing for resistance to beet eelworm, experiments on the variability arising in techniques for such tests are described. In pot tests with sugar beet, the variation in the number of cysts on plants of the same line under standard conditions is very high for all methods of inoculation, making detection of small differences in resistance impossible. Also, seasonal conditions affect cyst production. A technique for routine screening for resistance, involving the addition of hatched larvae to seedlings in small pots, is described. Selection for tolerance to attack, and the possible occurrence of resistance breaking biotypes are also discussed. Because of the great variation encountered in pot tests, the necessity for careful planning of experiments and care in interpretation of results is stressed.

1418* Tribe, H. T.

On the Parasitism of *Sclerotinia Trifoliorum* by *Coniothyrium Minitans*.

Trans. Brit. Mycol. Soc. 1957, **40**, 489–99.

Coniothyrium minitans Campb. is pathogenic to *Sclerotinia trifoliorum* Erikss., the causal agent of clover rot. It is recorded for the first time in England and its natural distribution on sclerotia of *S. trifoliorum* is studied. Experiments are described on artificial infection of buried sclerotia by *C. minitans* applied to soils as spore suspensions or mixed with them as cornmeal-sand preparations. A cornmeal-sand culture, mixed intimately with either a loamy sand or a heavy clay, killed 85 99 per cent. sclerotia within 11 weeks. The soils remained highly infective for at least 14 months. The possibilities of *C. minitans* for control of clover rot are discussed.

1414* Williams, T. D.

Development of Isolated Female Larvae of the Potato-root Eelworm (*Heterodera rostochiensis* Woll.).

Nature, Lond. 1957, **180**, 1000.

Females, developing from single larvae placed on separate potato tuber slices buried in moist sand, remained white until the tenth week. No eggs were found when they were opened at this time.

Females developing under similar conditions, but on tuber slices to which 2000 larvae had been added, had reached the yellow stage of development and contained embryonating eggs by the sixth week.

These results are in agreement with those of other workers and suggest that reproduction in the absence of males does not occur in *H. rostochiensis*.

"Giant cells" were found in tuber tissue associated with the developing cysts. One of the isolated females had a gelatinous extrusion reminiscent of the egg-sac found in other *Heterodera* spp. but not hitherto described in *H. rostochiensis*.

1465* Williams, T. D.

Potatoes Resistant to Root Eelworm.

Proc. Linn. Soc., Lond. 1956–7 (1958), Sess. 169, 93–104.

A brief account is given of the discovery of plants in the Commonwealth Potato Collection which are resistant to the potato root eelworm (*Heterodera rostochiensis*), and of the potato breeding programmes based on these plants.

Experiments were conducted using eelworm resistant plants of *Solanum andigena*, *S. vernei* and a resistant F_1 clone from an *S. andigena* × susceptible potato cross. All the plants used were provided by Dr H. W. Howard of the Plant Breeding Institute, Trumpington. The two eelworm populations used were from adjacent sites in Feltwell Fen, Norfolk.

Resistant *S. andigena* plants were found to produce the eelworm hatching factor in amounts similar to those produced by the susceptible varieties investigated. The number of larvae entering the roots of *S. andigena* plants was also similar to that found in susceptible varities. Many apparently mature male eelworms were found in *S. andigena* roots but few developing females were seen.

The *S. vernei* material studied produced little of the hatching factor; larval invasion was also much less than in *S. andigena*. Hardly any larval development, either male or female was observed in *S. vernei*.

Pot and field tests of *S. andigena* plants and the resistant F_1 clone showed that considerable reductions in the egg content of eelworm infested soil occurred when these plants had been grown. The reductions were most marked in the pot tests, though after two years field cultivation of resistant potatoes, the eelworm population level (eggs/gm. soil) was only 16·9 per cent. of that at the beginning of the experiment.

Both pot and field tests showed that the yield of resistant potatoes was reduced by high eelworm population levels.

Attempts were made to reinfect resistant plants with the few cysts which occasionally developed on their roots; there was no evidence, however, that the contents of these few cysts were better able to develop into mature females on resistant plants than the contents of cysts taken at random from the soil population used in the experiment.

The potential value of the resistant potatoes so far used is discussed, together with some of the implications of the resistance-breaking populations of *H. rostochiensis* now know to exist in Britain.

1417* Winslow, R. D. & Williams, T. D.

Amoeboid Organisms attacking Larvae of the Potato-root Eelworm (*Heterodera rostochiensis* Woll.) in England and the Beet Eelworm (*H. Schachtii* Schm.) in Canada.

Tijdschr. PlZiekt. 1957, **63**, 242–3.

Eelworm-attacking amoeboid organisms have been isolated from soil samples taken in Feltwell Fen, Norfolk, and Essex County, Ontario. These organisms closely resemble an organism (*Theratromyxa weberi*) found attacking *H. rostochiensis* in the Netherlands.

Descriptions are given of some of the ways in which the behaviour of the English and Canadian organisms differ from the Dutch form.

It is thought that such organisms are not likely to prove of practical importance in the control of plant-parasitic nematodes.

PLANT BREEDING AND GENETICS

Hudson, P. S.

Fodder Plants.

Nature, Lond. 1958, **182**, 702–3.

Hutchinson, J. B.

Cotton in East and Central Africa. Pp. 367–79.

Contr. to *Rhodesia and East Africa.* Compiled and edited by F. S. Joelson.

(East Africa and Rhodesia, London, 1958. Price 25s.)

Hutchinson, J. B.

Genetics and the Improvement of Tropical Crops. An Inaugural Lecture. Pp. 30.

(Camb. Univ. Press, 1958. Price 3s. 6d.)

The improvement of crop plants has been an important factor in producing greatly increased yields from agricultural land in temperate climates. More recently, these techniques have been applied to the improvement

of tropical crops. Modern theories and practice in plant breeding are discussed, and, especially, how the study of genetics can contribute to the efficiency of plant improvement schemes. It is shown that a reconsideration of the plant breeder's approach to the problems of crop improvement is needed. In particular, the relationship between the selective improvement practised by the plant breeder and its occurrence in nature. Only a recombination of the qualities found in existing plants can produce new varieties. Much of the plant breeder's time in the past has been devoted to the production of pure lines, at the expense of variability, and to the search for single genes of wide effect. It is suggested that more could be achieved if greater care were taken to conserve the natural variability, and if the gene-balance found in successful plants were considered more carefully. At the same time, the plant breeder must re-examine his objectives. Improvements in crop plants have only come when the search for a particular character has been undertaken. The needs of the farming community must be studied closely and work on crop improvement be directed by these needs. Though examples are taken from the study of tropical plants the conclusions drawn are of general application

SOIL SCIENCE

CHILDS, E. C.

Physics of Land Drainage. Pp. 1–66.

Contr. to *Drainage of Agricultural Lands.* Ed. by J. N. Luthin.

Agronomy Monographs, Vol. VII. (American Soc. Agronomy, Madison, 1957. Price $11.00.)

This discussion of those physical properties of soil which determine the soil-water interrelationship begins with an account of the nature of soil constituents and the internal soil architecture. This is followed by a discussion of the static equilibrium of soil water, both in respect of colloidal and surface-inactive materials. The laws of soil water movement are developed, and the kinds of drainage problem for which these laws may be applied are then analysed.

1467* CHILDS, E. C. & YOUNGS, E. G.

Nature of the Drain Channel as a Factor in the Design of a Land-drainage System.

J. Soil Sci. 1958, **9**, 316–31.

Drainage theory is customarily discussed on the assumption that the drainage channel is uniformly permeable. In practice such channels often consist of short lengths of relatively impermeable pipe separated by gaps. It is shown here that the appropriate modification to the theory in order to embrace such channels is to substitute an equivalent permeable channel of smaller radius.

Experiments described here enable one to evaluate the equivalent drain radius, and show that this radius is not solely dependent upon the geometry of the gappy channel but is markedly affected by the ratio of intensity of rainfall to soil hydraulic conductivity. In the examples shown a tenfold increase of rainfall rate causes a hundredfold increase of effective drain radius.

1468* COLLIS-GEORGE, N. & YOUNGS, E. G.

Some Factors Determining Water-table Heights in Drained Homogeneous Soils.

J. Soil Sci. 1958, **9**, 332–8.

The effect of the depth of impermeable floor below the drain level on water table heights in homogeneous soils, drained by a uniform system of ideal drains, for steady state conditions with various rainfall intensities, was investigated by means of hydraulic model and electric analogue experiments. Agreement was obtained between the two series of experiments which indicated that, for a given ratio of rainfall intensity to hydraulic conductivity, the water-table height midway between the drains decreased as the depth of the impermeable floor below the drain was increased from zero, tending towards a constant height when the ratio of the depth of the impermeable floor below the axis of the drain tube to the half spacing of the drains approached 0·3. In addition, in the experiments with a deep impermeable floor, agreement was found with the analytically obtainable solution of the problem with an infinitely deep floor. Water-table heights observed in the non-steady state hydraulic experiments approximated to those of the steady state with uniform distributions of flux cutting the water table for corresponding equal mean distributions, calculated from the drain discharge.

1436* EDE, A. N.

Continuously Formed Concrete Tube for Drainage.

Agric. Engng. 1957, **38**, 864–6.

The technique of using unpumpable concrete of low water content for forming underground tubes involves vibratory feeding and consolidation under pressure. The mix can be graded to give drain wall permeabilities exceeding the highest soil permeabilities normally met. The large moleplough implement developed to give effect to the method has a gradient control, and is semi-mounted on a slow speed tracklayer.

1439* EDE, A. N.

Hydraulic Comparison of Land Drains and the Determination of Effective Diameters.

J. Agric. Engng Res. 1958, **3**, 9–16.

A hydraulic sand tank method has been used for making rapid *ad hoc* comparisons between various drain installation types. By subjecting to test a series of ideal drains of various diameters the function of diameter

in controlling performance under known boundary conditions has been ascertained. A test of a practical drain under similar conditions enables its performance to be matched with that of an ideal drain of a certain diameter, a relation which does not appreciably vary with the operating conditions. The relative discharge data for variously gapped, spaced and perforated drains are presented. The broad effect on drainage design is discussed.

1433* Ede, A. N.

Innovations in Land Drainage Methods.

J. Instn Brit. Agric. Engrs. 1958, **14**, 8–23.

Examination of the basic processes of field under-drainage enables the requirements of the installation operation to be formulated. To improve on conventional trenching methods there is need for new techniques. Of the material available for use with the low-cost mole-plough technique, concrete has been examined for its physical properties. Two distinct systems have been evolved as alternatives, and field operations have been undertaken to test the equipment and the products. Work with similar objectives has been carried on abroad with interesting results.

1461* Ede, A. N.

Recent Developments in Land Drainage.

Agric. Rev., Lond. 1958, **4** (3), 6–13.

Considerable research remains to be done on some aspects of the controlled use of soil water in agriculture. The limited objectives of the work on tube installation here and elsewhere are outlined. A pattern of intersecting "grid" drains is suggested as feasible with the new techniques of installation, for groundwater control.

Hutchinson, J. B., Manning, H. L. & Farbrother, H. G.†

On the Characterization of Tropical Rainstorms in Relation to Runoff and Percolation.

Quart. J. R. Met. Soc. 1958, **84**, 250–8.

The statistical characterisation of tropical rainstorms is considered. Linear relationships are demonstrated between log duration and rate, and between log amount and rate.

The fate of rainfall when it reaches the ground is then considered, and it is shown that from the linear regression of amount of rain and rate, together with runoff data, percolation rates can be estimated. The consistency of estimates of percolation rate is demonstrated from data from Namulonge, Uganda, and from the Ozark Highlands in Arkansas.

† Work carried out at the Cotton Research Station, Namulonge, Uganda.

1444* McAleese, D. M. & McConaghy, S.

Studies on the Basaltic Soils of Northern Ireland. III. Exchangeable-cation Contents of Sand, Silt, and Clay Separates.

J. Soil Sci. 1958, **9**, 66–75.

Results are given of the exchangeable calcium, magnesium, sodium, and potassium contents of the sand, silt, and clay fractions separated by purely physical methods from sixteen horizons, mainly subsoils from basaltic soil profiles in Northern Ireland. Relatively high exchangeable-calcium values are recorded, ranging from 6·9–20·9 m.e. per cent. for sands, from 9–28 m.e. per cent. for "silts", and from 8·3–35 m.e. per cent. for clay separates.

Exchangeable-magnesium values are also high, particularly for separates from subsoils with imperfect drainage, and values as high as 17·2, 27·3, and 32·2 m.e. per cent. are recorded for sand, silt, and clay separates, respectively. The exchangeable-magnesium contents usually increase with depth in the subsoil and in many cases the exchangeable-magnesium values for silts are as high as or higher than values for corresponding clay separates. Comparisons of the values for sands, "silts", and for corresponding clays suggest that the high values exhibited by the silts (and often by the sands) cannot be attributed, to any considerable extent, to incomplete dispersion, e.g. to the presence of normally dispersible clay aggregates in the silts or sand separates. It is suggested that these high values and the associated high cation-exchange capacities of these silts (and coarser fractions) may be due to the presence of partially weathered rock minerals which may be broken down, e.g. by acid treatments and dispersion procedures prior to detailed examinations.

1451* McAleese, D. M. & McConaghy, S.

Studies on the Basaltic Soils of Northern Ireland. IV. Mineralogical Study of the Clay Separates ($< 2\mu$).

J. Soil Sci. 1958, **9**, 76–80.

The clay separates ($<2\mu$) isolated from the horizons of ten basaltic soil profiles are shown by X-ray analysis to have a mixed mineralogical composition; the type and amount of each mineral present being dependent on the drainage conditions within the profile.

Kaolin, the end product of weathering, generally predominates in surface horizons. Vermiculite is formed in well-drained profiles, but where gleying symptoms are evident vermiculite is replaced by montmorillonite, the amount of which increases with increased degree of waterlogging. Illite occurs in only two profiles to any appreciable extent.

It is inferred that soil separates other than clay are contributing to the cation-exchange capacity of these soils.

1452* McAleese, D. M. & McConaghy, S.

Studies on the Basaltic Soils of Northern Ireland. V. Cation-exchange Capacities and Mineralogy of the Silt Separates (2–20μ).

J. Soil Sci. 1958, **9**, 81–8.

X-ray and chemical studies of silt separates (2–20μ) from basaltic soils were made to determine the origin of the rather high cation-exchange capacities (C.E.C.) found for these separates. The silts as isolated by the usual method of mechanical analysis consisted in the main of quartz and feldspars with variable amounts of clay minerals which occurred as aggregates. These aggregates were of two types:

(*a*) Composed of clay-size particles, i.e. $< 2\mu$ cemented or bound into silt-size aggregates by "free" sesquioxides of which the basaltic soils have a high content. The aggregates were disrupted by reduction and the clay particles subsequently released.

(*b*) "Pseudo-aggregates" which were shown to be individual particles of silt-size dimensions and having a flaky appearance. These particles were either vermiculitic (under good drainage conditions) or montmorillonitic (under poor drainage conditions), and it is suggested that they form intermediate products in the weathering of primary-rock minerals to clay minerals.

Whilst the major contributor to the C.E.C. of the silts was undoubtedly the "pseudo-aggregates" and to a lesser extent the true clay aggregates, most of the silt separates had a much higher C.E.C. than implied by their mineralogical composition.

1469* McAleese, D. M.

Studies on the Basaltic Soils of Northern Ireland. VI. Cation-exchange Capacities and Mineralogy of the Fine-sand Separates (0·02–0·2 mm.).

J. Soil Sci. 1958, **9**, 289–97.

The fine sand separates (0·02–0·2 mm.) from five basaltic soil profiles have considerable cation-exchange capacities (C.E.C.) ranging from 16·5–31·4 m.e. per cent. Only a small part of the C.E.C. is due to clay minerals (diameter $< 2\mu$) cemented into aggregates of fine-sand dimensions by free sesquioxides.

Mineralogical studies of the fractions obtained, after separation by the bromoform technique, show all heavy mineral groups (s.g. $> 2{\cdot}85$) to have a high content of pyroxenes (principally augite) followed by the opaque minerals (mainly magnetite). The heavy groups have small C.E.C., i.e. $< 7{\cdot}5$ m.e. per cent., as expected from the mineralogical composition.

In the light fractions (s.g. $< 2{\cdot}85$) which account for 57–80 per cent. of the total fine-sand separates, quartz predominates in fractions from surface horizons of the profiles. In the lower horizons where quartz is less abundant, greenish-yellow particles (pseudo-aggregates) predominate and comprise over 45 per cent. of the light fractions. Whilst zeolites occur only in negligible amounts and feldspars do not represent more than 10 per cent. of the light fractions, yet the C.E.C. of these fractions are considerable, ranging from 41·7–72·4 m.e. per cent. Refractive-index measurements and colour indicate that the pseudo-aggregates are mainly chlorites. They must be individual particles, since prolonged reduction failed to cause any further disruption.

The calculated values for the C.E.C. of the pseudo-aggregates range from 90–110 m.e. per cent.; the same order of magnitude as that for vermiculite and montmorillonite.

X-ray photographs of the isolated pseudo-aggregates from three fine sands show that the particles are of two types: (*a*) principally vermiculitic under good drainage conditions, (*b*) principally montmorillonitic where the drainage conditions are poor. Chlorites could not be detected, but there was a small amount of kaolinite and some amorphous material.

It is suggested that the pseudo-aggregates are individual particles representing an intermediate stage in the weathering of ferromagnesian rocks to the clay minerals, vermiculite or montmorillonite.

The high C.E.C. of the fine sands are due to (i) a small contribution from clay minerals (diameter $< 2\mu$) present in the fine sands as the result of aggregation and cementation by free sesquioxides, and (ii) a major contribution from the pseudo-aggregates, which have C.E.C. between 90 and 110 m.e. per cent.

1454* Nicholson, H. H. & Firth, D. H.

Effect of Ground Water-Level on the Yield of some Common Crops on a Fen Peat Soil.

J. Agric. Sci. 1958, **50**, 243–52.

An account is given of a field experiment in the control of ground water-level in a Fen peat soil, together with its results on the yields of crops in a six-course rotation.

The seasonal variations in rainfall are presented in terms of potential evaporation and soil moisture deficit. The effect of the water-level on the moistness of the soil above it is indicated. Even in a wet summer, drying was perceptible within 18–20 in. of the ground water-level between successive falls of rain.

The fluctuations of the ground water-levels are discussed. Those of the high water-levels were chiefly due to individual incidences of rain causing rises short in duration, but sufficient in the case of water-levels within 20 in. of the surface to cause total waterlogging and surface ponding. Those of the deep water-levels were most influenced by evaporation, with steady and persistent falls during any rain-free period.

The deterioration of the physical condition of the soil over high water-levels is shown in the result of sieving tests. In 6 years the loss of tilth over water-levels within 20 in. of the surface was very marked and was discernible over those as low as 30 in.

The possibilities of effectively using high ground water-levels occasionally in soils in good condition are shown by the results with celery and potatoes.

In the case of sugar beet and kale marked failures resulted over water-levels within 20 in. of the surface in wet growing seasons; the trends as a whole favour ground water-levels of 30–35 in.

With 1-year ryegrass leys, the yield of dry matter increased with depth of water-level and this trend was even more marked in the yield of crude protein.

1435* O'Donnell, T., Edwards, D. H., Collis-George, N. & Youngs, E. G.
Recording of Pressure Distributions in Porous Media during Fluid Flow Experiments.
J. Sci. Instr. 1958, **35**, 63–4.
A null-point method is described of recording in a short time interval pressure distributions in a porous medium during fluid flow experiments. Small cells, buried at numerous points in the porous material, measure the pressure distribution which is recorded in a separate laboratory.

1429* Perrin, R. M. S.
Clay Mineralogy of Some Tills in the Cambridge District.
Clay Min. Bull. 1957, **3**, 193–205.
Four ice advances have been recognised in East Anglia but only two of these, the Lowestoft and the Gipping, have deposited till in the Cambridge area. The clay fractions of these tills have been investigated and compared with those of the Oxford, Ampthill, Kimeridge and Gault Clays, the Lower Greensand and the Chalk, all of which outcrop in the district and could be expected to contribute materials to the tills.

The value of clay mineralogical analysis as a means of measuring directions of ice-movement is critically discussed.

An outline account is given of the more important processes of weathering and soil-formation which occur on the Gipping till in the Breckland area.

1416* Youngs, E. G.
Moisture Profiles during Vertical Infiltration.
Soil Sci. 1957, **84**, 283–90.
Theoretical moisture profiles calculated from the equation

$$\frac{\partial c}{\partial t} = \nabla \cdot D \nabla c + \rho g \frac{\partial K}{\partial z}$$

are compared with experimental profiles for two cases: (*a*) vertical infiltration into initially dry columns of porous materials with the surfaces maintained at saturation; and (*b*) the equilibrium condition of vertical infiltration at a constant rate into columns which drain to a water table. Good agreement is found between theory and experiment in both cases.

1478* Youngs, E. G.
The Redistribution of Moisture in Porous Materials after Infiltration. I.
Soil Sci. 1958, **86**, 117–25.
The limitations of the diffusion concept of moisture flow in porous materials is discussed, and it is argued that further advances in moisture flow problems involving both wetting and draining, of which the redistribution of infiltration water is an example, must be made by considering the changing potential distribution in the porous body. For the example cited it is shown that the potential distribution abruptly changes at the cessation of infiltration and the beginning of redistribution.

Moisture profiles were obtained during experiments on the redistribution of moisture after infiltration in the horizontal case and were presented in a dimensionless form. From a knowledge of the hydrological properties of the porous materials used, utilising a special method for obtaining the wetting moisture characteristic so as to produce the relevant experimental conditions, and by making certain assumptions, an estimate was made of the initial transition moisture content from the draining to the wetting zone. This agreed with experiment and explained why redistribution readily occurred in one material and not in another. The moisture profiles obtained were explained qualitatively by considering the potential distribution in the porous body.

OTHER PAPERS

NICHOLSON, H. H. **Improvement of Field Drainage.** *Esso Fmr.* 1957, 9 (4), 16–18.

1438* NICHOLSON, H. H. **Drainage, Irrigation and Water Supply for Crops.** *J. Yorks Agric. Soc.* 1958, **109**, 27–34.

MISCELLANEOUS

1383* Buttress, F. A. *assisted by* Hughes, G.
Abbreviations.
Quart. Bull. Int. Ass. Agric. Libns. 1957, **2**, 164–74; 1958, **3**, 51–9; 99–107.
Three further instalments (CFAL–ZWM) of abbreviations of professional scientific and commercial bodies, not confined to agriculture. The reader may also refer to an earlier work by Buttress (1954) entitled *World List of Abbreviations of Scientific, Technological and Commercial Organisations*, London.

Hutchinson, J. B.
Malthas Once Again.
Camb. Rev. 1958, **79**, 551, 553.

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THE LIBRARIAN HAS PLEASURE IN BRINGING THE FOLLOWING WORKS TO THE READER'S NOTICE

ALTSCHUL, A. M. (Ed.). **Processed Plant Protein Foodstuffs.** Pp. XV + 955, with many Figs and Tables. (Academic Press, Inc. [Academic Books, London], New York, 1958. 186s.)

BAILEY, J. W. **Veterinary Handbook for Cattlemen. 2nd ed.** Pp. X + 389, illustrated. (Springer, New York, 1958. $5.00.)

BALDWIN, E. **Dynamic Aspects of Biochemistry. 3rd ed.** Pp. XX + 526, with 39 Figs and Diagrams, and 37 Tables. (Camb. Univ. Press, London, 1957. 37s. 6d.)

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HUTT, F. B. **Genetic Resistance to Disease in Domestic Animals.** Pp. XIV + 198, with 30 Figs and 17 Tables. (Constable, London, 1958. 35s.)

JACOB, A. **Magnesium. The Fifth Major Plant Nutrient.** Transl. from the German by N. Walker. Pp. XII + 159, with 10 Figs and 8 Plates. (Staples Press Ltd., London, 1958. 40s.)

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